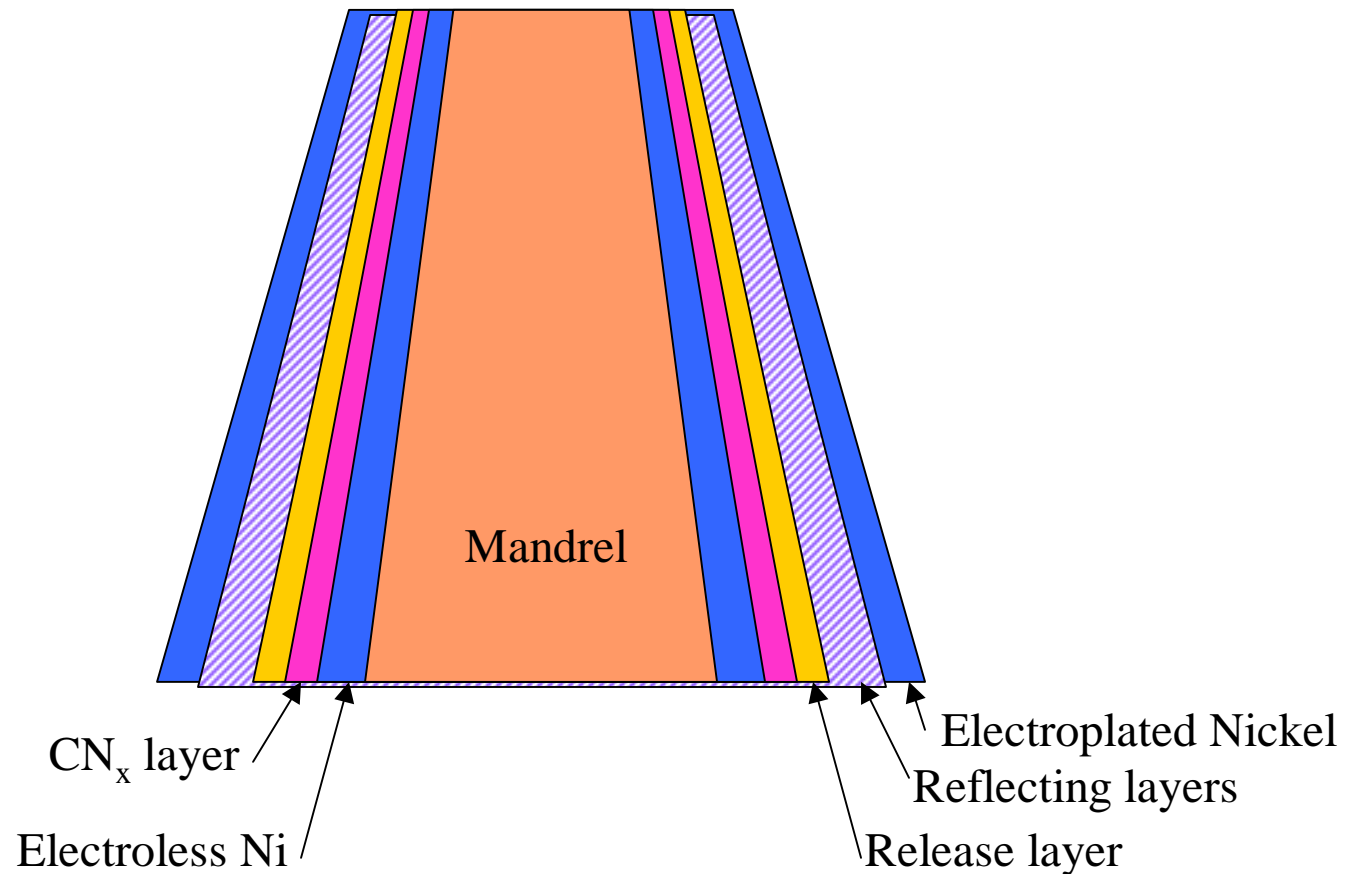


X-Ray Mirror Fabrication for Constellation -X

Investigators:

Mel Ulmer (P.I.) and Robert Altkorn, Physics and Astronomy,
Yip-Wah Chung, Materials Science and Engineering,
Anita Madan and Michael Graham, Advanced Coating
Technology Group, Northwestern University

Coating Design for X-ray Mirrors

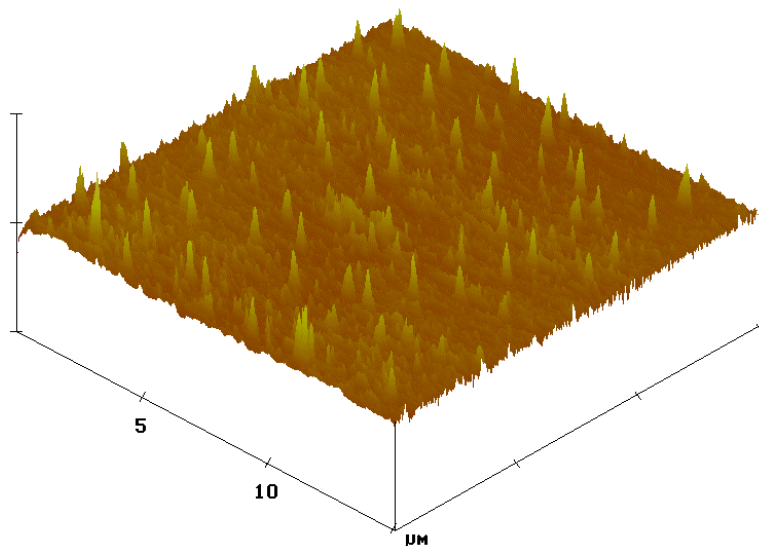


01/21/00

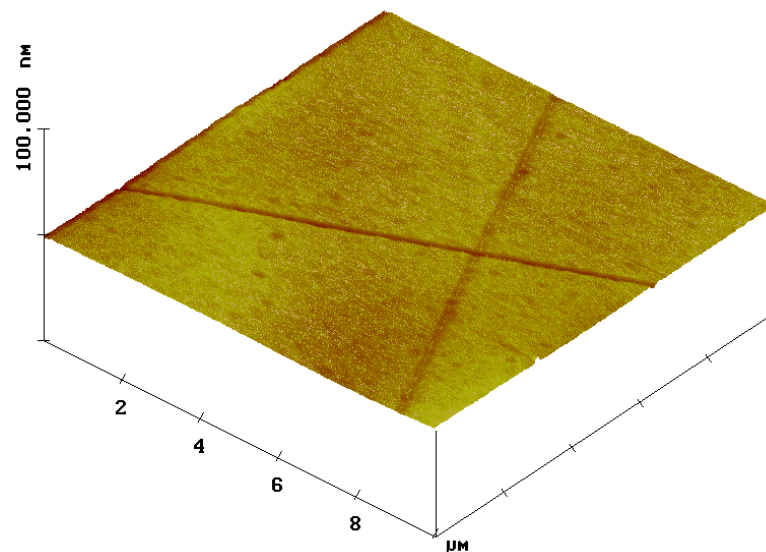
GSFC-NASA Review

Effect of pulsed dc-bias

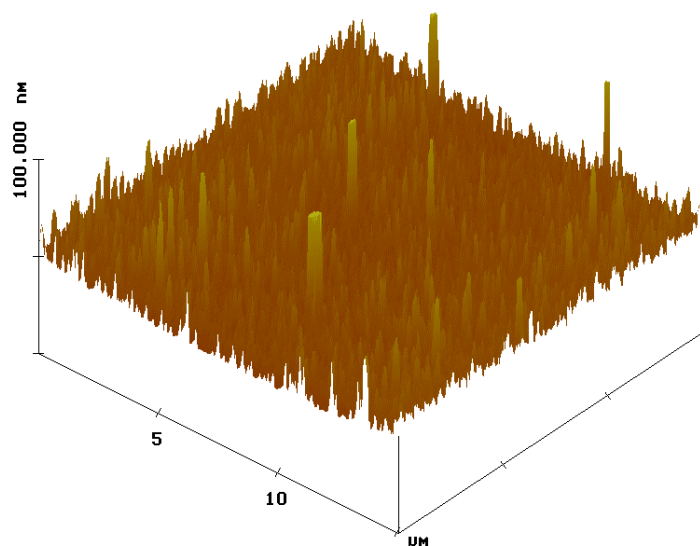
Rotation = 4 rpm



Uncoated
Roughness ~ 2.786 nm

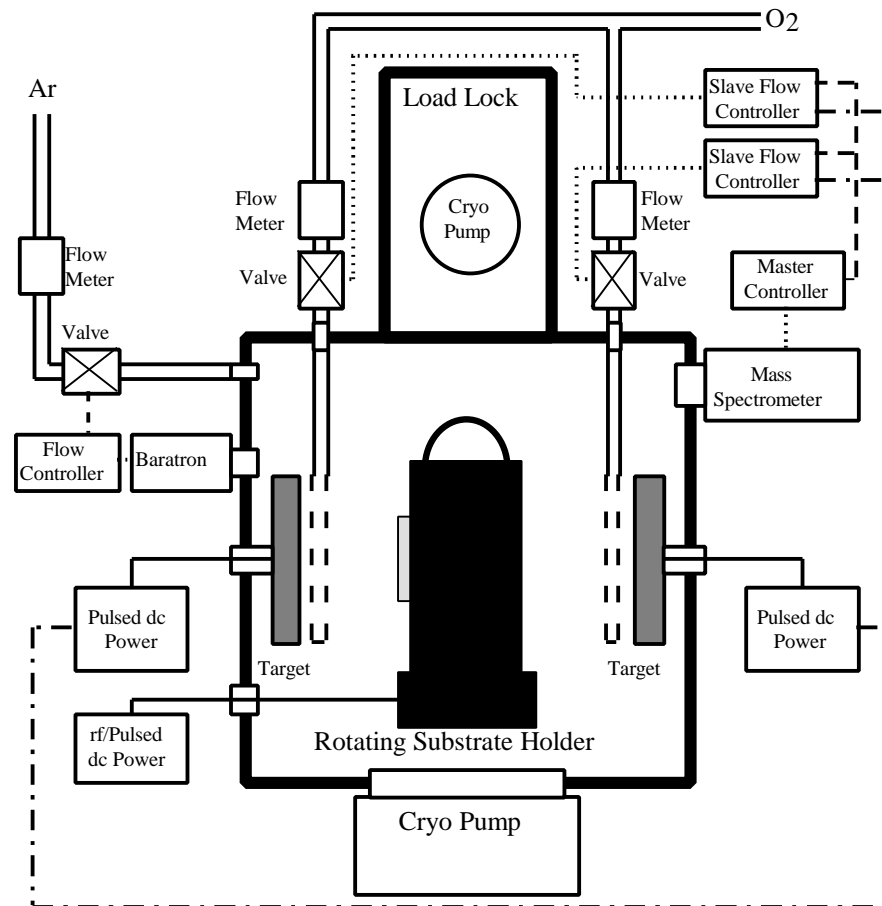


-150 V
Roughness ~ 0.417 nm



-200 V
Roughness ~ 5.2 nm

Dual Cathode Unbalanced Magnetron Sputtering System



01/21/00

GSFC-NASA Review

ACTG Dual Cathode Sputtering System



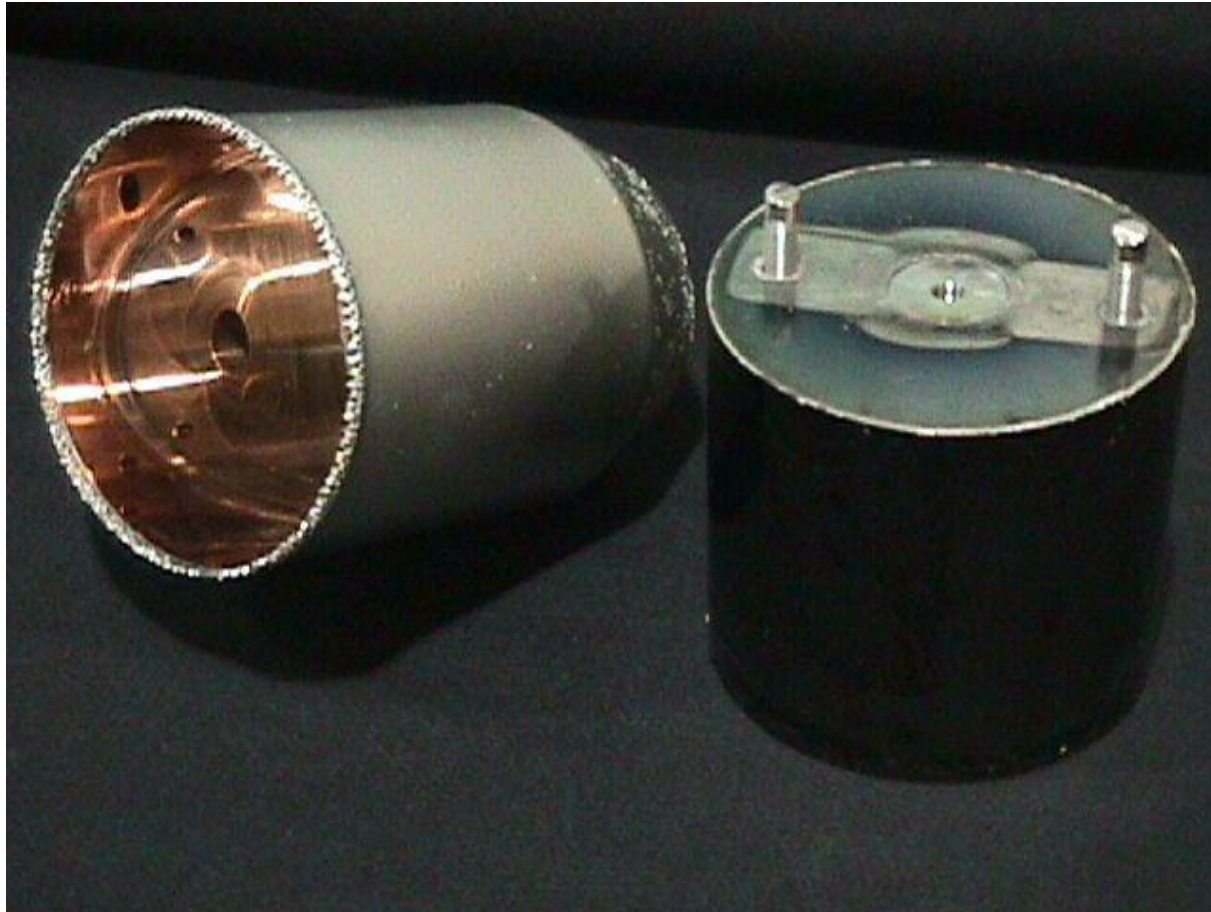
01/21/00

GSFC-NASA Review

New PVD System with *In-Situ* Monitoring and Controls for Graded Multilayer Deposition

- Up to 4 cathodes, up to 24” long
- Hollow cylindrical cathode for CNx or release layer
- Ion source for controlled ion bombardment
- Programmable rotation speed, shutters, gas flows, and bias voltage
- Plasma monitor for characterizing ion/atom ratio
- Ellipsometer for in-situ monitoring of coatings
- RF, DC, and pulsed DC bias capability
- Mass spectrometer for gas monitoring and pressure control

Conical Mirror and CNx Coated Mandrel after Separation



01/21/00

GSFC-NASA Review

Conical Mirror Before Cu Release layer is Removed



01/21/00

GSFC-NASA Review

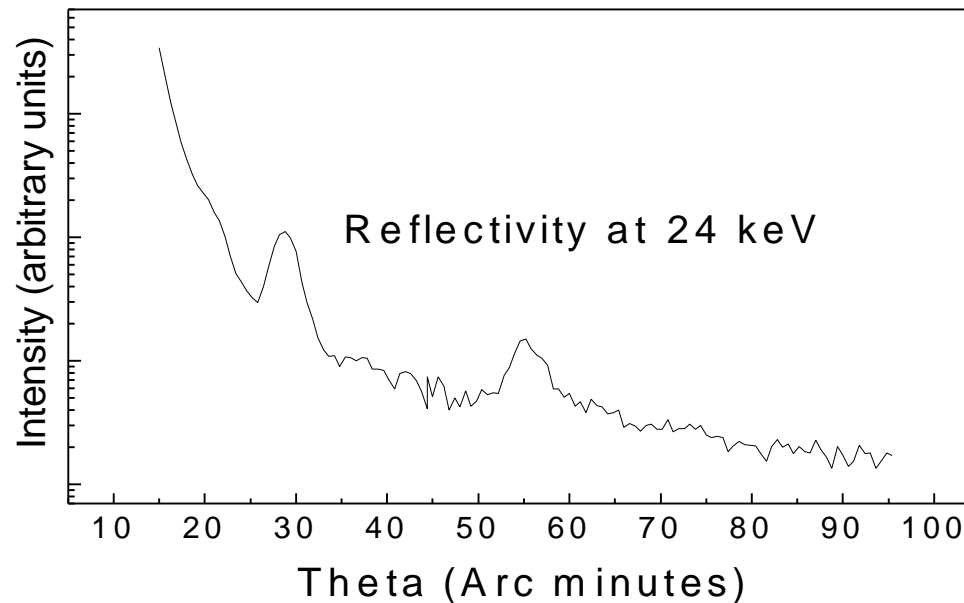
Conical Mirror After Removal of Cu Release Layer



01/21/00

GSFC-NASA Review

X-ray Reflectivity from Initial APS Trials



Reflectivity vs. angle from a conical replica. Surface roughness of mandrel is ~ 60 nm. The reflectivity measurements were done at the Advanced Photon Source, Argonne National Laboratory.

Conclusions

- Smoothing of Ni surface by CNx deposition as hard, reusable surface
- Successfully deposited release layer
- Successful deposition of multilayers on conical mandrel
 - Reflectivity (67%) of W/Si layers on flats indicative of smooth sharp interfaces
- Successful development of Ni-electroforming process for shell
- Successful removal of mirror from mandrel at release layer
- Good reflectivity peaks from replicated mirror

Future Developments

- Optimize deposition conditions for depositing the CNx and release layers
- Improve multilayer performance and develop graded multilayer deposition
- Demonstrate Wolter I mirror fabrication and performance on high quality surface
- Demonstrate multiple replication of mirrors from a mandrel